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(6) COLOUR OR MONOCHROME FILMS IN LABORATORY EXPERIMENTS ON THE ACQUISITION OF GROUND TARGETS FROM MEDIUM ALTITUDE

by

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SUMMARY

This Report describes three laboratory simulation experiments to compare target acquisition performance obtained using monochrome and colour films of identical routes and targets. It is concluded that monochrome films give similar results to those obtained with colour films for relatively prominent targets capable of being acquired at long ranges in:-

(1) experiments which involve first-pass detection range measurements, or

(2) experiments involving potential range measurements.

The adequacy of monochrome films for simulating the acquisition of more difficult targets, only capable of being acquired at short ranges, or more difficult navigation tasks remains untested.

Departmental Reference: WE 223

CONTENTS

1 INTRODUCTION

The use of films in laboratory simulation experiments of air-to-ground target acquisition raised the question of whether or not monochrome films were adequate for this purpose or whether colour films were necessary to provide a more realistic representation of the scene as observed from an aircraft. At first sight it seemed important that the simulation of a coloured ground scene should be carried out by using a colour film rather than a monochrome one, because it is readily possible to envisage targets of strong colour contrast. However, when a large number of air-to-ground colour films were examined it was remarkable how very few showed any strong colour effects. In some cases the monochrome effect was so marked that an assurance was obtained from the team who took the film that the colour was, in fact, true to life, and not altered by a processing fault. Most of the films examined were a blend of greens or browns, depending upon the terrain over-flown and the season of the year.

In the films used here, almost the only exceptions to this occurred when a lake or river reflected the blue sky and so showed up as a blue patch in an otherwise green or brown landscape. Due to the fact that the water was often of low luminous contrast, it did not always show as a corresponding white patch on the monochrome films. Target detections, too, are usually made at ranges where the atmosphere has attenuated the colour contrast strongly. The exception to this is, perhaps, for very low level flight against difficult targets, where the detection ranges will be short.

In recent air-to-ground target acquisition flight trials colour and monochrome films were taken simultaneously. These films have been used to compare the target acquisition performance obtained during laboratory simulation experiments. As far as is known, these are the only comparisons of this nature which have been made in the UK.

2 THE ADVANTAGES AND DISADVANTAGES OF COLOUR OR MONOCHROME

Before considering the experiments which were carried out to compare colour and monochrome films, it is pertinent to consider the factors which affect their use in laboratory target detection experiments. Table 1 summarises the advantages and disadvantages of the two types of film material.

The advantages of monochrome film are its low cost and its ease and cheapness of processing, even when the best, controlled conditions are called for[1]. This is true for both negative/positive systems or reversal/positive systems. Indeed, as far as cost is concerned, it appears to be slightly cheaper

to make reversal copies from an original positive (and these will be of high resolution, almost as good as the original) than to produce a negative and make degraded prints from this. Reversal film processing also does not exhibit the 'adjacency' effect which makes some scientific measurements off negative films difficult.

Monochrome negative film is preferred in that errors in the original exposure can be corrected more easily than for negative colour film or reversal/positive monochrome or colour films, and a good print can be produced over a wide range of exposures above or below the correct one. However, if a good, automatic exposure meter is used there is no great difficulty in producing good colour or monochrome reversal/positive prints, except for scenes of extreme brightness range.

Thus, from the point of view of:-

(a) cost of materials

(b) cheapness and ease of processing

(c) resolution available on the projection print

monochrome reversal/positive film is preferred to colour film or monochrome negative film. Against this, the monochrome film is a monochromatic representation of the coloured scene used in making visual detections in flight. Whether or not this one factor outweighs those of cost and ease of production in making colour films necessary for laboratory detection experiments is one which is examined in the present experiments, as reported in the next section.

3 COLOUR VERSUS MONOCHROME EXPERIMENTS

3.1 General

Three experimental comparisons were carried out between monochrome and colour films, using two batches of film, referred to as Series 1 and Series 2, obtained during target acquisition trials carried out in Australia.

The Series 1 films were taken from a height of about 2000 ft at a speed of 400 kn, over five different types of terrain, with 24 routes in each terrain.

A - grazing farmland

B - hilly desert

C - flat desert

D - flat tropical country

E - mountainous tropical country.

The main objective of the trials in which the Series 1 films were taken was to obtain visual and televisual target acquisition data. In consequence, although all routes were filmed in monochrome, only a limited number were filmed, also, in colour, and these were not taken simultaneously with the monochrome films, but on different days. However, from an examination of the films a batch of 27 pairs were considered suitable for the measurement of potential ranges, i.e. the maximum possible detection ranges. These measurements were made in Experiment 1.

The Series 2 films were taken at two speeds (250 and 400 kn), and at three heights (200, 750 and 2000 ft) over three of the terrains (A, C and D) mentioned above. Flights were made over 16 new routes in each terrain. As there was no television detection in this part of the trials, two cine cameras were mounted in the aircraft and monochrome and colour films were taken simultaneously over each route for all the speed and height combinations used (a total of 144 pairs of films). It was possible to make comparisons between the films for 129 of the pairs, the remainder being unsuitable because of film defects or navigation errors. Using these pairs of films two further experiments were carried out:-

(a) Experiment 2, a comparison based on potential ranges obtained by one operator who was very familiar with the films.

(b) Experiment 3, a comparison based on the potential and first-run detection ranges obtained in the laboratory by sixteen subjects.

3.2 Experiment 1. Potential range measurements using Series 1 films

In this experiment the potential ranges of targets on the monochrome and colour films were measured by one subject who was very familiar with the film material. The results are given in Table 2 and Fig.1, which shows the scatter of the points about the ideal line.

In this experiment, and also in the ones which follow, the subject was seated in front of a screen on to which the films were projected with such geometry that the images subtended real-life angles at the subject's eyes.

As the mean ranges for all 27 routes (all at the same height and speed but over five different types of terrain) were very similar, they were considered together. The mean ranges and standard deviations were:-

Monochrome 5.70 km ± 1.43 km

Colour 5.69 km ± 1.36 km

and there is no significant difference between these two ranges.

The correlation coefficient between ranges for the same targets in monochrome and colour is very low at 0.2 suggesting that whatever factors were causing the variability in the results the differences between targets were not dominant factors. This result could be due to the fact that the films were taken at different times, implying that weather, lighting or exposure differences were more important than the target differences in this particular sample of targets.

3.3 Experiment 2. Potential range measurements using Series 2 films

As in Experiment 1, measurements were made by one subject, and comparisons between the two types of films made for the various conditions of heights, speeds and terrains as shown in Table 3. This gives the raw data, the mean ranges and standard deviations obtained for the numbers of targets (up to eight in each case) for which range measurements are given for any one speed, the eight targets in any one terrain were the same for all three heights, but a second set of eight targets was associated with the second speed. However, the two sets of targets did not differ, to any great extent, as to size and type.

The mean ranges and standard deviations for each condition of speed, height and terrain in Table 3 show a very small difference in each case between the values with colour and monochrome films, and in only five cases is the mean range for colour greater than that for monochrome. The spread of values within a terrain/speed/height condition is sometimes quite large, probably due to target differences, leading to the high values of the standard deviations.

The raw data from Table 3 are plotted in Figs.2 (for 250 kn) and 3 (for 400 kn) and these both show a good distribution about the 45° line, indicating that the monochrome ranges did not differ to any great extent from those obtained from colour films.

The correlation coefficient between colour and monochrome ranges is now very high, at 0.955, showing that the factors which were deliberately varied had a much bigger effect than the random variability. The fact that the films were taken simultaneously may have eliminated some of the randomness which caused the low correlation coefficient with the Series 1 films.

It might have been expected that if there were any effect of colour at all it would be at the lowest altitudes. To investigate this, the data from Experiment 2 were put into a four-factor analysis of variance, found in Table 4. The most striking thing about the analysis was that all the colour interactions, to the highest level, contributed little to the total sum of squares so that

it can safely be concluded that whatever the effects of the other factors, colour had no effect on them. In particular, the interaction with height is not significant at any level so that there is no evidence for any more effect of colour at lower altitudes. It is interesting that in the analysis of variance table the main effect of colour, taken as a fixed effect, is significant against the residual, although against the general scatter of the situation (pooled residual) it is a very minor effect.

The small, but significant, superiority of monochrome film over colour in this experiment probably reflects a high resolution or other aspect of higher film quality for monochrome film.

3.4 Experiment 3. First-run detection and potential ranges using Series 2 films

This was the main experiment undertaken to compare monochrome and colour films. The subjects used were either experienced aircrew or scientific staff who had a knowledge of the problems of target detection and some experience of detecting targets from films in the laboratory.

The targets used were chosen to be as similar as possible (for example single buildings, small observation towers) and in all cases only the films taken at 750 ft altitude were used, as these gave larger target sizes than did the films taken from 2000 ft and were not as subject to terrain screening as were those taken from 200 ft. All the targets chosen were in the same geographical area, an area of rolling farmland (Terrain A) in Australia, very similar to UK territory.

Using the same projection geometry as was used in Experiments 1 and 2, the subjects viewed colour and monochrome films of four flight routes and their associated targets.

The films were arranged as follows:-

Film 1, 250 kn, monochrome Film 2, 250 kn, colour	Same four routes and targets (Targets A) for each film.
Film 3, 400 kn, monochrome Film 4, 400 kn, colour	Another four routes and targets (Targets B), the same for each film.

They were viewed by a block of four subjects in the following order:-

Subject 1, Film 1 then 4
Subject 2, Film 4 then 1
Subject 3, Film 2 then 3
Subject 4, Film 3 then 2.

This block was then repeated three times, with a total of sixteen subjects.

As briefing material they were given a strip-map of the area, at 1:250 000 scale, on which were marked the start of the film, the proposed aircraft track to the target, one or more *en route* fix-points and the target position. Descriptions of the fix-points and targets were also provided, together with 6 × 6 inch monochrome photographs of the targets.

The subject was shown a stationary frame on each film corresponding to the start position shown on the map, and when he felt ready the film was run and he was asked to press an event button when he had detected what he thought was the target. After detection the film was stopped and the subject asked to indicate what he had detected, so that the experimenter knew whether or not the correct target had been detected.

To ensure that data was obtained on target acquisition and not in the navigation phase, the experimenter indicated the fix-points as they came into view, roughly half-way along each route.

Finally, a measure of potential detection range for each target was made by running the film backwards, from the target, and having the subject press the event button when he could no longer see the target.

Three results were obtained for each target:-

(a) correct target seen or not seen

(b) if seen, at what range

(c) the potential detection range.

For each subject, viewing two films each of four targets, eight measurements of each of (a), (b) and (c) were possible, four for colour films and four for monochrome. No subject viewed any target more than once so that all detections were first-run detections.

4 RESULTS OBTAINED FROM THE THIRD EXPERIMENT

4.1 Experimental data

Tables 5 and 6 show the first-run and potential ranges, respectively, obtained by all the sixteen subjects.

From the experimental design it was possible to make direct comparisons between colour and monochrome films as an average effect over the subjects and targets used. To increase the sensitivity of the experiment the targets had been chosen to be as similar as possible and at a particular speed the same targets were used for both types of films so that any target effect should

be common to both. The remaining difference is, then, a possible subject effect, but a preliminary analysis showed that the differences between subjects were small enough to allow them to be considered as one integrated sample within a batch of films.

Analysis was carried out on the two halves of the experiment (Targets A and B) separately to see if there was a large effect of target sample (or speed, as this and the target sample were completely confounded). As a number of targets were missed during the first-run detections, analysis of variance techniques could not be used and the analysis was based, simply, on success rates and mean ranges.

4.2 Data analysis

Cumulative distributions of detection ranges and potential ranges for both colour and monochrome films, are plotted from the data or Tables 5 and 6 and shown in Figs.4 and 5 respectively. It is immediately apparent that any effect of colour on first-run acquisition or potential ranges is not large.

The success rates on 'first runs' are as follows:-

Target sample	A	B	A + B
Colour	$\frac{30}{32}$	$\frac{30}{32}$	$\frac{60}{64}$ (0.94)
Monochrome	$\frac{30}{32}$	$\frac{27}{32}$	$\frac{57}{64}$ (0.89)

For these results there is no significant difference between colour and monochrome for Sample A, but for Sample B colour is slightly significantly better (at the 5% level of significance) than monochrome.

Mean ranges (km) on 'first runs' for the separate target samples are:-

Target sample	A	B	Mean
Colour	3.51	2.71	3.11
Monochrome	3.87	2.39	3.17
Mean	3.69	2.56	-

For neither sample is there any significant difference, at the 10% level, between colour or monochrome films but the trend is seen to be different between the two target samples.

Potential ranges (km)

Target sample	A	B	Mean
Colour	4.48	4.36	4.42
Monochrome	5.29	4.08	4.69
Mean	4.99	4.22	-

For Sample A potential ranges from monochrome films are significantly greater (at the 5% level of significance) than those from colour films. For Sample B there is no significant difference (at the 10% level) between the ranges obtained with the two kinds of films. Again, the trend is different for the two target sets but is the same as for the first-runs above.

The consistently opposite trends in the first run and potential ranges above probably represents genuine small differences between the groups of subjects as each diagonal in the data matrices represents data from one of the two subject groups. Consequently, the trend should not be taken to reflect any genuine colour effect; the slight imbalance between subject groups is accounted for when Targets A and B are pooled, and so does not affect the overall conclusion.

4.3 Subjective opinions

During the experiment the subjects were asked to state their preference for the monochrome or colour films. Even amongst the aircrew, used to observing a natural, coloured scene, opinions were about equally divided, as between one type of film and the other. Rather surprisingly, any slight bias there was, was in favour of the monochrome films.

5 DISCUSSION OF RESULTS

The results obtained from the three experiments described here are summarised in Table 7, and show that the use of colour film has no advantages over the use of monochrome films for laboratory experiments which involve:-

a) potential range measurements for relatively prominent targets, or

b) first-pass detections also of relatively prominent targets.

Both types of film give rise to mean acquisition or potential ranges which are substantially the same, and to similar success later in detecting targets.

The result is not wholly unexpected as at the relatively-long acquisition ranges encountered with these particular films, albeit taken under conditions

of up to 50 miles meteorological visibility, colour saturation is so low due to atmospheric effects that the difference between colour and monochrome film is slight. Detections were made, generally, within areas of more-or-less even shades which, whether greens or browns on the colour films or greys on the monochrome films were not vastly dissimilar. Also, the targets used did not differ markedly in colour from their surroundings.

It is not possible to say that there will be no conditions under which colour films would be superior to monochrome ones. There will certainly be conditions under which the use of colour films would be important, for example, to detect a particularly-coloured target from amongst several others of similar shape but of different colours. Nor can it be said that colour has no relevance to navigation or target attack at low level for items seen at short ranges where colour contrast is less attenuated and might help to differentiate certain ground details. However, the present experiments have at least established one area where colour simulation is of little extra value.

The films used in Experiment 3 were taken from an altitude of 750 ft above target level, but the analysis of Experiment 2 suggests that the results are valid for a height range of 200 to 2000 ft.

From these comparisons it would seem that for general laboratory experimental use the majority of in-flight air-to-ground films should continue to be taken in monochrome. With a reasonable control of exposure and processing it is possible to produce films of very high quality. Copies of these films, for use in experiments, can be produced quickly and cheaply, and as scratching usually prevents a film from being used for more than one experiment this results in a considerable cost saving.

6 CONCLUSIONS

The present experiments have shown that whilst there may be certain cases of laboratory target detection experiments where the use of colour films are vital there are, in general, no advantages to be gained from the use of colour rather than monochrome films for experiments which involve the acquisition of target at long acquisition ranges or potential ranges over the height band of 200 to 2000 ft. This is because the detection ranges are so long that detections are made in regions where, due to atmospheric effects, no strong colour differences appear.

Targets seen at shorter ranges may well show more effect of colour contrast so that the present results need to be extrapolated with care.

The use of monochrome films can result in a significant saving over the cost of using colour film in an experiment.

Table

THE ADVANTAGES AND DISADVANTAGES OF

Item	Monochrome	
	Advantages	Disadvantages
1 Film types	Available as negative/positive or as reversal/positive films	-
2 Cost	Low-cost materials (either process)	-
3 Processing	Cheap and quick	Not always to specificatio if processed in bulk
4 Film speeds	High speeds to suit most weather conditions for both processes	For reversal processing ma need trial processing to obtain correct processing conditions for fast films
5 Exposure	High exposure latitude for negative/positive film	Reversal positive film nee a carefully-controlled exposure for high quality
6 Film resolution	Can be very high for reversal/ positive film	Not always very high under commercial processing conditions. Negative/ positive film gives lower resolution than reversal/ positive
7 Prints	Prints can be made to any specified density and are cheap to produce	
8 Scene rendering	-	Monochrome

Table 1

VANTAGES OF COLOUR OR MONOCHROME 16 mm FILMS

	Colour	
ntages	Advantages	Disadvantages
	Available as negative/positive or as reversal/positive films	-
	-	Cost of materials 2-3 times that of monochrome
specification n bulk	-	Not easy to process locally. Costs 2-3 times as much as monochrome processing. Not always to specification if processed in bulk
rocessing may cessing to processing fast films		Can be much slower than monochrome films and this could be a disadvantage in bad weather
ive film needs ntrolled igh quality		For both negative/positive and reversal/positive processes needs carefully-controlled exposure to obtain true colour rendering
y high under cessing egative/ gives lower n reversal/		No figures available under same conditions as monochrome films. Colour elements are sometimes distracting when film viewed from close to
		Colour prints cost 2-3 times as much as monochrome prints and are not always reliable in colour *vis-à-vis* the original
	Can be a faithful representation of the original scene	Not always accurate colour rendering (see 7 above)

Table 2

POTENTIAL RANGE COMPARISON - EXPERIMENT 1, SERIES 1 FILMS

Terrain	Monochrome mean ranges (km)	Colour mean ranges (km)
A (Grazing farmland)	9.39	6.14
	8.47	7.59
	6.17	5.24
	6.23	4.59
B (Hilly desert)	4.54	5.79
	5.97	4.42
	5.33	4.98
C (Flat desert)	4.66	5.64
	3.63	6.42
	3.14	3.75
	4.92	3.61
	5.99	6.58
	7.16	7.41
	5.46	6.71
D (Flat tropical)	6.54	8.99
	5.14	4.97
	3.64	5.58
	3.86	8.55
E (Mountainous tropical)	5.70	5.46
	7.97	5.96
	5.76	6.43
	6.80	3.35
	5.06	3.32
	5.42	4.63
	5.03	4.76
	5.93	5.58
	6.02	5.30
All terrains (mean ranges for 27 routes)	5.70	5.69
Standard deviation	1.43	1.36

Correlation coefficient between monochrome and colour films = 0.213

Table 3

POTENTIAL RANGE COMPARISON, EXPERIMENT

Terrain	250 kn 200 ft		250 kn 750 ft		250 k 2000 f
	Monochrome	Colour	Monochrome	Colour	Monochrome
A (Grazing farmland)	7.70	6.41	8.18	7.20	7.39
	5.01	4.97	3.68	3.58	6.36
	3.32	2.94	5.08	2.94	7.08
	3.12	4.01	5.26	5.64	7.32
	1.61	1.70	9.07	4.65	6.98
	6.64	5.08	6.65	6.94	8.30
	5.73	5.89	6.51	6.26	7.17
	9.41	8.74	7.09	7.97	12.17
Mean ranges	5.32	4.96	6.44	5.65	7.85
Standard deviations	2.58	2.19	1.78	1.78	1.84
C (Flat desert)	4.35	3.29	3.45	2.80	6.97
	1.86	1.83	2.74	2.88	3.79
	1.35	1.26	3.08	3.15	11.65
	2.55	2.01	10.30	8.06	7.14
	5.33	3.83	9.45	5.62	8.62
	8.23	6.70	7.51	4.79	4.95
	2.18	2.23	3.50	4.51	
	2.53	2.33			
Mean ranges	3.55	2.94	5.72	4.54	7.16
Standard deviations	2.30	1.72	3.02	1.89	2.86
D (Flat tropical)	4.59	2.80	2.20	1.89	10.79
	2.74	2.68	7.76	7.42	6.01
	4.59	4.91	4.82	4.14	13.60
	1.95	2.11	13.15	15.98	8.41
	1.76	1.68	5.38	4.56	5.39
	1.89	2.17	3.08	1.79	9.07
	3.17	3.15	3.91	3.82	
			4.61	4.86	
Mean ranges	2.96	2.80	5.61	5.56	8.88
Standard deviations	1.21	1.04	3.47	4.57	3.05

Correlation coefficient between mo

Table 3

, EXPERIMENT 2, SERIES 2 FILMS (RANGES IN km)

250 kn 2000 ft		400 kn 200 ft		400 kn 750 ft		400 kn 2000 ft	
Monochrome	Colour	Monochrome	Colour	Monochrome	Colour	Monochrome	Colour
7.39	7.56	2.24	1.85	4.86	4.94	7.06	7.48
6.36	6.77	9.64	9.12	8.88	6.62	7.86	5.41
7.08	5.64	5.42	5.65	7.77	8.65	11.12	14.97
7.32	5.64	2.20	2.06	2.61	2.41	5.71	2.50
6.98	6.48	4.97	4.33	3.30	6.18	6.67	6.15
8.30	10.62			6.65	6.24	5.64	6.27
7.17	6.11			3.67	5.51	3.68	3.88
12.17	10.97			7.09	5.41	12.17	8.60
7.85	7.47	4.89	4.60	5.60	5.74	7.49	6.90
1.84	2.15	3.05	2.99	2.34	1.77	2.85	3.80
6.97	5.33	2.24	2.29	4.11	4.18	8.51	7.33
3.79	4.09	1.52	1.27	4.89	3.79	5.56	4.36
11.65	9.38	1.91	1.83	4.83	4.42	7.18	5.30
7.14	5.64	1.47	2.76	2.12	2.26	17.21	17.59
8.62	7.54	1.20	1.24	3.67	3.15		
4.95	4.64	3.55	3.44	2.67	2.82		
		1.44	1.44	7.13	7.91		
		13.54	12.10				
7.16	6.10	3.36	3.30	4.26	4.08	9.62	8.65
2.86	2.00	4.18	3.64	1.77	1.84	5.19	6.08
10.79	11.83	3.48	3.39	5.06	6.17	9.03	9.18
6.01	5.39	1.32	1.42	3.44	2.41	4.97	5.45
13.60	13.94	4.12	4.03	2.23	2.18	4.27	4.47
8.41	9.26	1.70	7.36	2.29	7.80	4.09	9.59
5.39	5.57	2.86	2.71	5.64	3.95	4.98	5.17
9.07	8.89	1.73	2.15	3.00	2.56	6.21	6.12
		2.47	3.06	2.33	2.67	5.35	4.92
				4.06	3.92	3.88	3.76
8.88	9.16	2.53	3.45	3.51	3.96	5.35	6.08
3.05	3.37	1.02	1.91	1.30	2.02	1.66	1.11

ıt between monochrome and colour = 0.955

Table 4

ANALYSIS OF VARIANCE FOR EXPERIMENT 2

	Sums of squares	Mean squares	Degrees of freedom	
Colour/monochrome (C)	5.02	5.02	1	
Terrain (T)	103.86	51.93	2	
Height (H)	1037.58	518.79	2	
Speed (S)	13.91	13.91	1	
C × T	5.46	2.73	2	Pooled residual, mean square 27.00 degrees of freedom 11
C × H	0.90	0.45	2	
C × S	5.93	5.93	1	
T × H	77.08	19.27	4	
T × S	74.00	37.00	2	
H × S	5.10	2.55	2	
C × T × H	10.56	2.64	4	
C × T × S	6.34	3.17	2	
C × H × S	3.10	1.55	2	
T × H × S	104.60	26.15	4	
C × T × H × S	3.36	0.84	4	
Total	1456.80		35	

Table 5

LABORATORY FIRST-RUN DETECTION RANGES (IN km),
EXPERIMENT 3, SERIES 2 FILMS

Subject	Routes at 250 kn (A) 2	7	14	15	Routes at 400 kn (B) 1	4	12	16
	Monochrome				Colour			
1	6.64	1.30	4.65	5.14	2.00	2.21	3.58	4.11
2	2.68	1.56	2.74	1.77	1.20	1.36	2.17	0.91
5	4.89	1.73	6.65	5.32	2.85	2.79	2.05	4.33
6	-	2.85	4.65	5.59	2.21	2.62	4.91	5.26
9	3.64	2.32	4.17	4.20	1.86	2.06	3.42	3.59
10	2.01	0.89	3.27	2.70	2.74	1.18	-	1.33
13	4.77	3.59	3.39	5.15	3.53	1.95	3.00	3.21
14	6.59	-	5.15	4.51	3.27	1.97	-	3.21
	Colour				Monochrome			
3	5.12	1.38	2.30	4.35	0.67	1.62	1.14	-
4	2.48	2.24	3.76	1.55	2.77	1.86	2.74	5.54
7	-	2.83	3.74	6.17	2.15	6.48	2.20	4.27
8	5.24	1.82	2.15	4.83	2.23	-	2.39	2.91
11	6.29	1.70	3.09	4.67	-	1.56	-	-
12	5.00	-	2.91	5.33	1.38	1.77	2.05	2.86
15	2.71	1.55	2.14	4.97	0.91	1.80	2.97	1.48
16	2.83	1.45	2.59	5.71	1.76	2.47	2.45	2.39

Mean ranges over all subjects and routes:-

Targets A } 250 kn monochrome 3.87 km
250 kn colour 3.57 km

Targets B } 400 kn monochrome 2.39 km
400 kn colour 2.71 km

Means with speeds combined:-

Monochrome 3.15 km
Colour 3.10 km

Table 6

LABORATORY POTENTIAL RANGES (km),

EXPERIMENT 3, SERIES 2 FILMS

Subject	Routes at 250 kn (A)				Routes at 400 kn (B)			
	2	7	14	15	1	4	12	16
	Monochrome				Colour			
1	7.27	4.05	5.23	6.36	3.97	3.85	4.41	4.41
2	6.36	3.61	5.00	5.24	4.20	3.12	4.79	4.56
5	7.94	4.22	6.80	6.39	4.36	3.74	6.12	5.1?
6	5.32	3.51	5.39	6.32	4.30	3.15	5.88	5.03
9	4.94	4.30	5.30	6.32	4.79	3.15	5.71	5.74
10	3.55	3.33	4.54	6.24	4.71	3.62	3.12	2.88
13	3.38	3.48	5.33	6.08	4.55	2.42	4.76	5.36
14	6.44	3.89	5.58	6.27	5.58	3.03	4.65	4.86
	Colour				Monochrome			
3	6.08	3.12	4.26	7.02	2.00	3.06	3.61	2.77
4	4.14	2.80	3.83	5.83	4.21	2.85	4.91	6.86
7	5.27	3.62	4.91	7.08	2.17	4.67	3.05	5.98
8	6.29	3.82	4.97	7.23	5.00	6.83	5.64	8.26
11	3.00	3.92	5.18	7.17	5.44	4.79	4.76	4.32
12	4.88	2.91	3.86	6.64	3.94	3.53	2.73	3.53
15	3.36	2.55	3.21	4.09	2.97	2.91	3.17	2.00
16	1.98	2.21	1.95	3.03	3.94	2.61	2.12	2.33

Mean ranges over all subjects and routes:-

Targets A
- 250 kn monochrome 5.29 km
- 250 kn colour 4.48 km

Targets B
- 400 kn monochrome 4.08 km
- 400 kn colour 4.36 km

Means with speeds combined:-

Monochrome 4.69 km
Colour 4.42 km

Table 7

SUMMARY OF FINDINGS FROM THE THREE EXPERIMENTS

Experiment	Main features	Main conclusions
1	Potential range measurements using Series 1 Australian films 2000 ft altitude, 400 kn 5 types of terrains	No difference between mean potential ranges obtained for either monochrome or colour film Monochrome:- 5.70 km Colour:- 5.69 km
2	Potential range measurements using Series 2 Australian films 200, 750, 2000 ft altitude 250 and 400 kn 3 types of terrains	No differences between mean potential ranges obtained for either monochrome or colour film for any height or terrain Monochrome / Colour 200 ft 3.77 km / 3.68 km 750 ft 5.19 / 4.82 2000 ft 7.55 / 7.39
3	First-run acquisition and potential ranges using Series 2 Australian films 750 ft altitude 250 and 400 kn 1 type of terrain	No differences between mean potential or acquisition ranges obtained for either monochrome or colour film Monochrome / Colour Acquisition ranges 3.15 km / 3.10 km Potential ranges 4.69 / 4.42
Overall conclusion		Monochrome films are as useful as colour films for the majority of laboratory experiments in target detection

REFERENCE

No.	Author	Title, etc.
1	W. F. Fielding	The Weapon's Department, RAE, air-to-surface target acquisition film library. Part I Collection and assessment of film material. RAE Technical Report 69191 (1969)

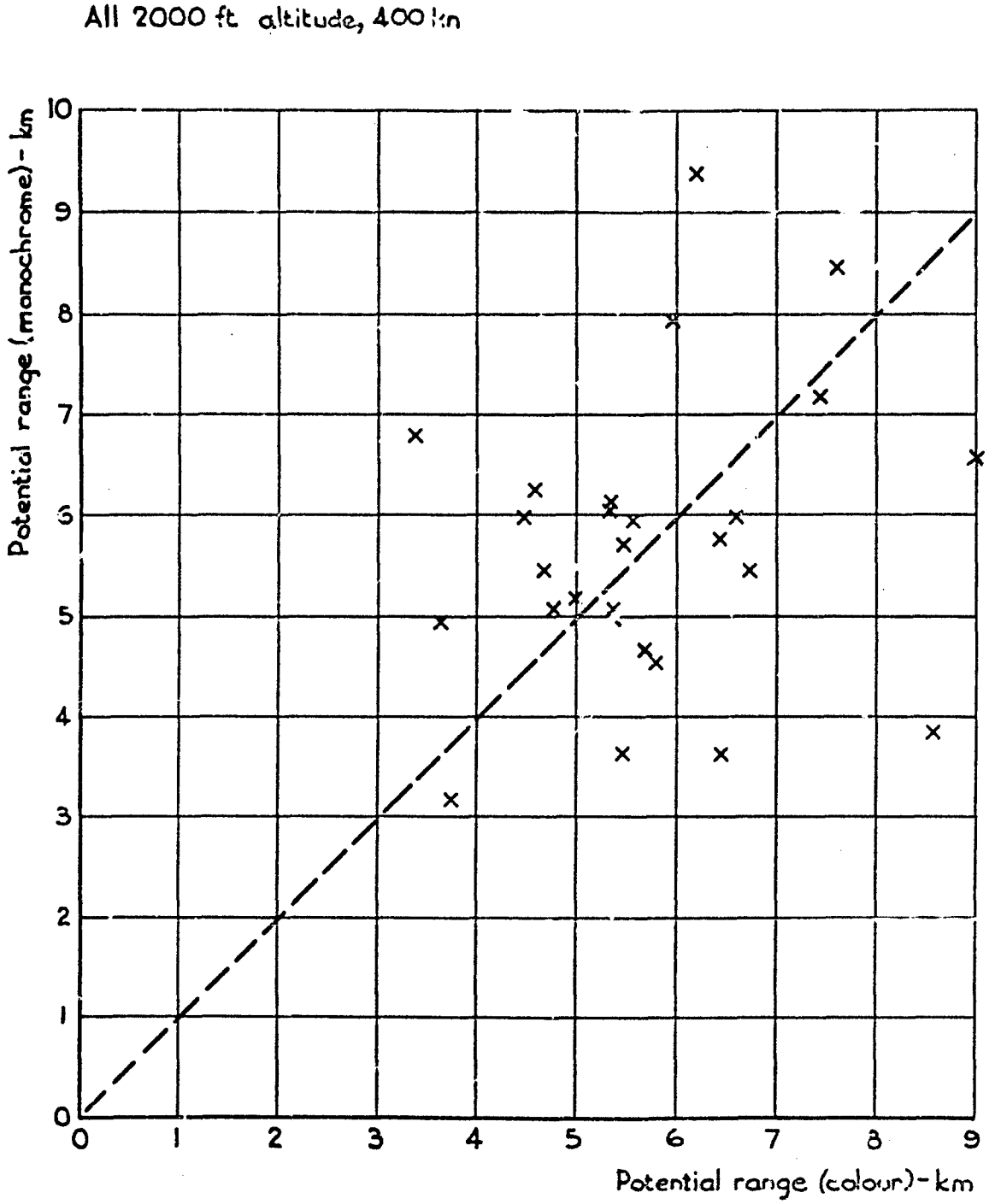


Fig. 1 Comparison between potential ranges for monochrome and colour films of series I

Fig.2

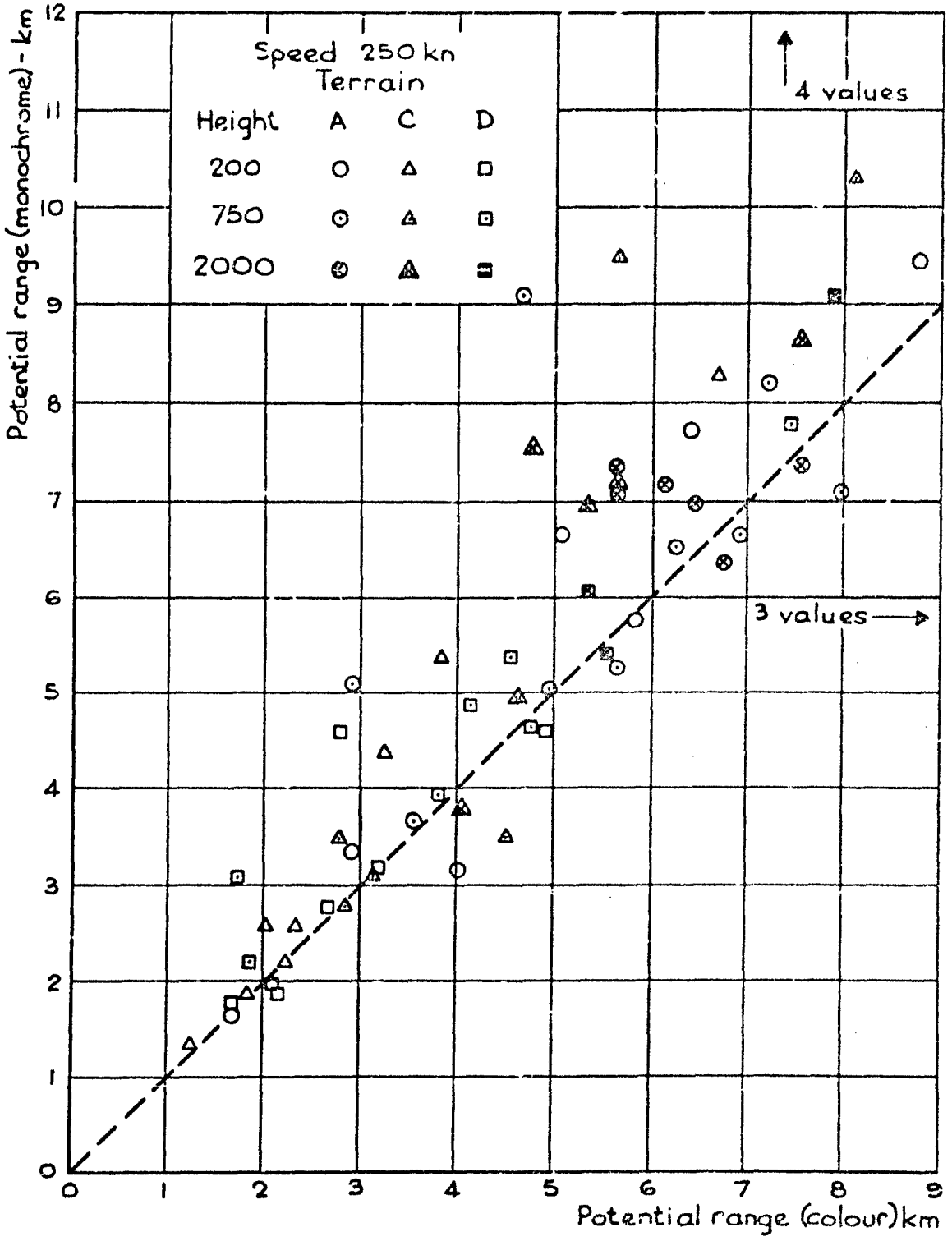


Fig.2 Comparison between potential ranges for monochrome and colour films (series 2, 250kn)

Fig.3

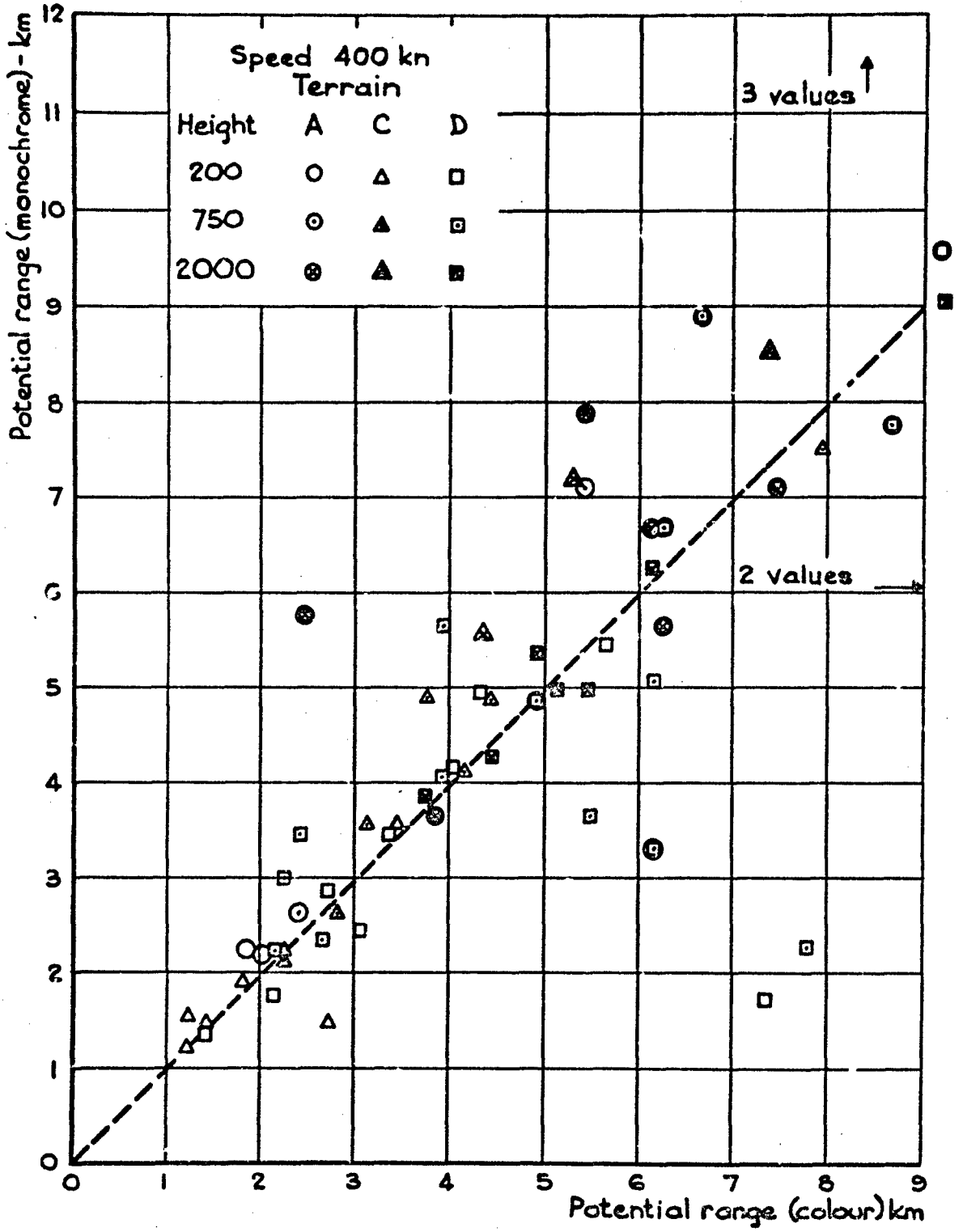
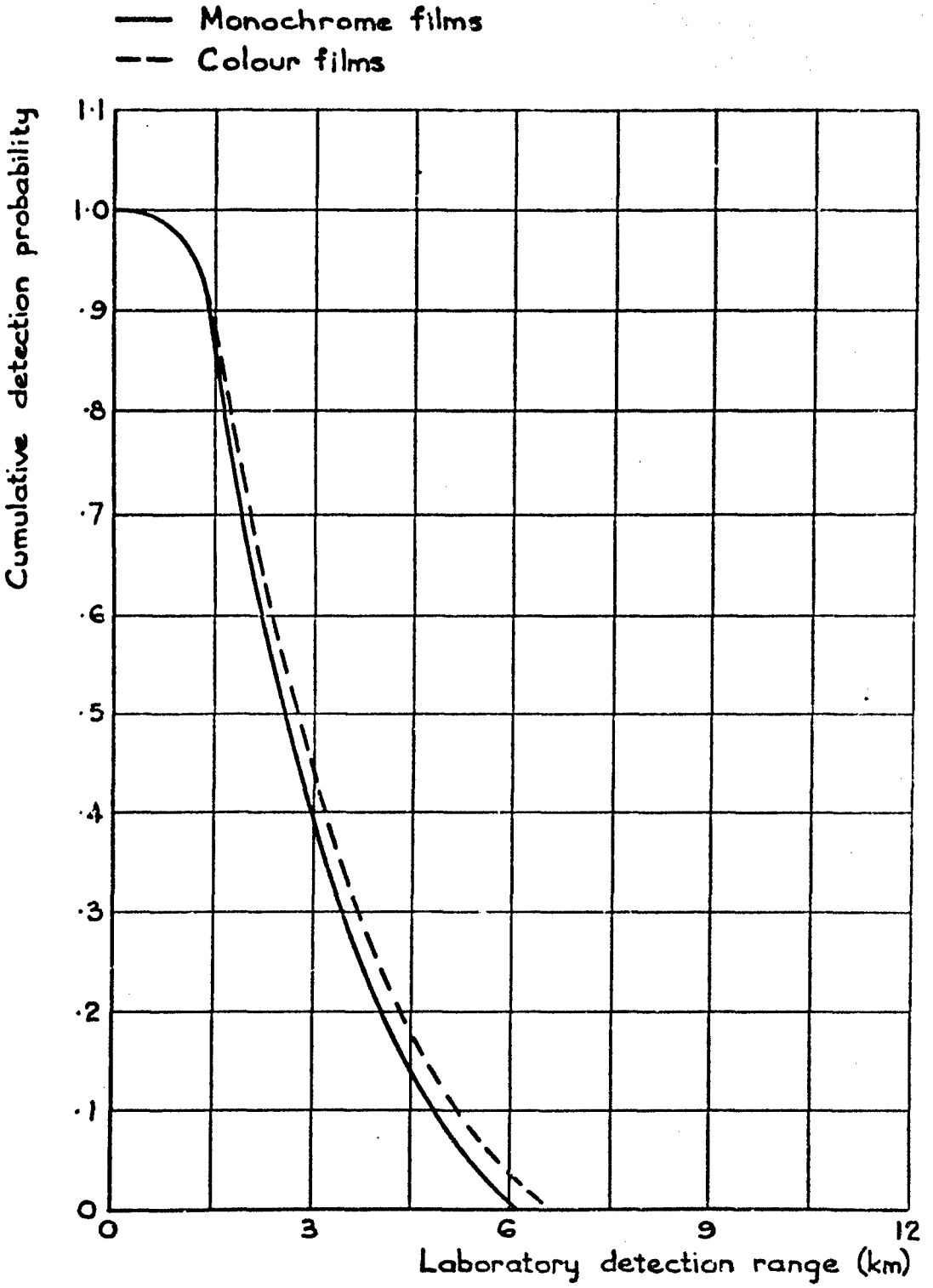


Fig. 3 Comparison between potential ranges for monochrome and colour films (series 2, 400kn)

Fig. 4



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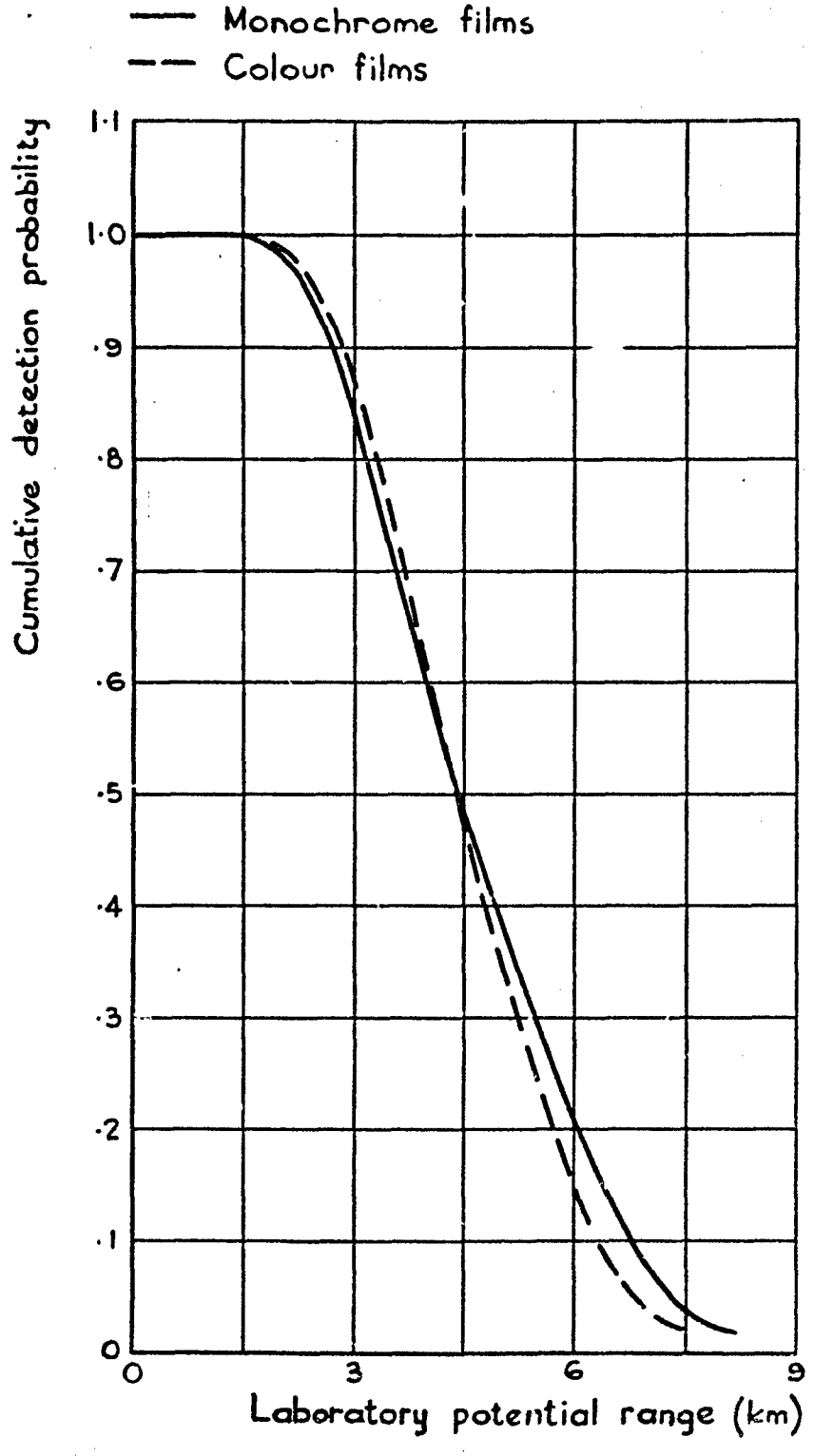
WE R.13274

Fig. 4 Laboratory first-run acquisition ranges for monochrome and colour films (from experiment 3)



TR 72064

Fig.5 Laboratory potential ranges for monochrome and colour films (from experiment 3)

WE 813275

Fielding, W. F.

COLOUR OR MONOCHROME FILMS IN LABORATORY EXPERIMENTS ON THE ACQUISITION OF GROUND TARGETS FROM MEDIUM ALTITUDE

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Royal Aircraft Establishment Technical Report 72064
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This Report describes three laboratory simulation experiments to compare target acquisition performance obtained using monochrome and colour films of identical routes and targets. It is concluded that monochrome films give similar results to those obtained with colour films for relatively prominent targets capable of being acquired at long ranges in:–

(a) experiments which involve first-pass detection range measurements, or

(b) experiments involving potential range measurements.

The adequacy of monochrome films for simulating the acquisition of more difficult targets, only capable of being acquired at short ranges, or more difficult navigation tasks remains untested.

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DETACHABLE ABSTRACT CARD

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